4 Management Measure for Protection of Wetlands and Riparian Areas

This chapter presents supporting information, including management practices, specific implementation examples, and costs and benefits, for the following management measure:

> Management Measure
>
> **Protect from adverse effects wetlands and riparian areas that are serving a significant NPS abatement function and maintain this function while protecting the other existing functions of these wetlands and riparian areas as measured by characteristics such as vegetative composition and cover, hydrology of surface water and groundwater, geochemistry of the substrate, and species composition.**

The purpose of this management measure is to maintain the water quality benefits of wetlands and riparian areas and to ensure that such areas do not become a source of NPS pollution as a result of degradation. The term *NPS abatement function* refers to the ability of a wetland or riparian area to remove NPS pollutants from runoff passing through the wetland or riparian area. Two examples of NPS pollution abatement functions performed by wetlands and riparian areas are (1) acting as a sink for phosphorus and (2) converting nitrate to nitrogen gas through denitrification. Wetlands and riparian areas have been shown to have useful functions for removing other NPS pollutants, including total suspended solids (TSS), sulfates, calcium, magnesium, and sediments. Table 4-1 shows results of several studies of the NPS pollution abatement functions of wetlands and riparian areas. The ability of wetlands and riparian areas to perform pollution filtration functions is determined by species composition, geochemistry, and hydrogeomorphic characteristics. Any changes to these characteristics can affect filtering capacities.

The nonpoint source pollution abatement functions performed by wetlands and riparian areas are most effective as parts of an integrated land management system that combines nutrient, sediment, and soil erosion control.

> **Reduction of NPS Pollutants in Coastal Plain Wetlands and Riparian Areas**
> A study performed in the southeastern United States coastal plain illustrates dramatically the role that wetlands and riparian areas play in abating NPS pollutants. It examined the water quality role played by mixed hardwood forests along stream channels adjacent to agricultural lands. These streamside forests were shown to be effective in retaining nitrogen, phosphorus, calcium, and magnesium. The study authors projected that total conversion of the riparian forest to a mix of crops typically grown on uplands would result in a 20-fold increase in nitrate-nitrogen loadings to the streams. This projected increase resulted from use of fertilizers (e.g., nitrates) to promote crop development and from the loss of nitrate removal functions previously performed by the riparian forest.
> Source: Lowrance et al., 1983.

Factors Affecting Removal Efficiencies

The properties of a particlar wetland or riparian area and of the surrounding watershed play a significant role in the ability of the wetland or riparian area to retain its existing wetland functions (such as food and habitat for animals, flood storage, and groundwater recharge) and serve an NPS pollution abatement function. Several factors determine the pollutant-removal efficiency of a specific wetland or riparian area, including the following:

- Frequency and duration of flooding
- Types of soil
- Slope of landscape
- Types of vegetation
- Balance of nitrogen and carbon
- Ratio of edge to area for the wetland or riparian area

The characteristics of the surrounding watershed affect the balance of wetland or riparian function and pollutant removal efficiency. Some of these characteristics are the land use practices in the watershed, the number and types of surrounding wetlands and riparian areas, and the climatic conditions in the area.

Multiple Benefits

EPA is encouraging the preservation and protection of wetlands and riparian areas because these natural systems have been shown to provide many other benefits in addition to NPS pollution reduction. The basis of protection involves avoiding and minimizing impacts on wetlands and riparian areas that control NPS pollution by maintaining the existing functions of these areas, including vegetative composition and cover, flow characteristics of surface water and groundwater, hydrology and geochemical characteristics of substrate, and species composition (Azous, 1991; Hammer, 1992; Mitsch and Gosselink, 1986; Reinelt and Horner, 1990; Richter et al., 1991; Stockdale, 1991).

The preservation and protection of wetlands and riparian areas is encouraged because these natural systems provide many benefits, in addition to providing the potential for NPS pollution reduction.

Wetlands and riparian areas also perform important functions such as providing a source of food, nesting material, habitat, and nursery areas for a variety of terrestrial and aquatic wildlife (Atcheson et al., 1979). Many animals whose development histories include an aquatic phase (amphibians, some reptiles, and invertebrates) need habitat provided by wetlands (Mitsch and Gosselink, 1993). Other important functions of wetlands and riparian areas include floodwater storage, erosion control, groundwater recharge, and maintenance of biological diversity. Protection of wetlands and riparian areas should allow for both NPS control and other corollary benefits of these natural aquatic systems.

Degradation Increases Pollution

Wetlands perform many water quality functions; when severely degraded, however, they can be a source of NPS pollution (Brinson 1988; Richardson, 1988). For example, the drainage of tidal wetlands underlain by a layer of organic peat can cause the soil to rapidly decompose and release sulfuric acid, which can significantly reduce pH (increase acidity) in surrounding waters. Removal of wetland or riparian area vegetation along the shorelines of streams, bays, or estuaries makes these areas more vulnerable to erosion because of increased water level fluctuation associated with storm events, concentrated runoff, and wave action. Activities such as channelization, which modify the hydrology of floodplain wetlands, can alter the ability of these areas to retain sediment when they are flooded and result instead in erosion and a net export of sediment from the wetland (Reinelt and Horner, 1990).

Permits to Protect Wetlands

A permit program administered by the U.S. Army Corps of Engineers, EPA, and approved states under section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the United States, including wetlands. The management measure and section 404 program complement each other, but the two differ in focus.

The management measure focuses on protecting wetlands that help to abate NPS problems, as well as on maintaining the functions of these wetlands. This protection can include preventing impacts resulting from upland development and upstream channel modifications that erode wetlands, change salinity, kill existing vegetation, and upset sediment and nutrient balances. The section 404 program focuses on protecting wetlands from physical destruction and other pollutant problems that could result from discharges of dredged or fill material. Table 4-2 shows many of the federal programs that affect wetlands in the United States.

Wetlands and riparian areas should be considered as part of a continuum of filters along rivers, streams, and coastal waters that together serve an important NPS abatement function.

4.1 Management Practices for Protecting Wetlands and Riparian Areas

The management measure for protecting wetlands and riparian areas generally will be implemented by applying one or more practices appropriate to a specific source, location, and climate. The four management practices listed below can be applied to implement the management measure for protecting wetlands and riparian areas. The following pages and Table 4-3 provide details about each practice.

Practice

Evaluate and document the NPS control potential of wetlands and riparian areas on a watershed or landscape scale.

- Wetland Evaluation
- Assessment of Functions and Values
- Programmatic Approaches to Wetland Protection
- Preliminary Treatment Practices

4.1.1 Wetland Evaluation

Wetlands and riparian areas should be considered part of a continuum of filters along rivers, streams, lakes, and coastal waters that together serve an important NPS abatement function. Examples of evaluating wetlands and riparian areas on a watershed or landscape scale were outlined by Whigham and others (1988). They found that a landscape approach can be used to make reasonable decisions about how any particular wetland might affect water quality parameters. Wetlands in the upper parts of the drainage systems tend to have a greater impact on water quality than those in lower reaches.

Wetlands and riparian areas are particularly sensitive to landscape disturbance, including fragmentation and changes in land cover. Wetlands and riparian areas covering large areas provide for more sustainable nonpoint source control within a watershed (Mitsch, 1992). Hanson and others (1990) used a model to determine the effect of riparian forest fragmentation on forest dynamics. They concluded that increased fragmentation would lead to lower species diversity and an increased prevalence of species that are adapted to isolated conditions. Naiman and others (1988) discussed the importance of wetlands and riparian areas as boundary ecosystems, providing a boundary between terrestrial and aquatic ecosystems.

Geographic Differences

The characteristics of wetlands and riparian areas are largely controlled by climate, landscape characteristics, vegetation, and soils. Regional variations in these controls can greatly affect how a wetland or riparian area functions within a watershed. Therefore, it is important to consider geographic variations when evaluating the potential NPS pollution control functions of wetlands and riparian areas. For instance, wetlands in arid or semiarid areas are typically associated with perennial springs and headwaters streams; that is, they are able to exist because they are near enough to the headwaters that the probability of erosive scour from flood flows is minimal. The upstream pumping of groundwater can disrupt the hydrology of cienagas and playas, two of the more common arid/semi-arid wetland types, where water is not abundant. These types of wetlands play an important role in NPS pollution control because of their location within the watershed or landscape. In addition, the characteristics of a watershed wield a strong influence on rivers, flooding patterns, and riparian wetlands. Western and eastern riparian wetlands in small watersheds tend to flood for a few months during spring thaw, whereas eastern bottomland forests (such as those along the Mississippi River) flood for several months. During these flood periods the wetlands capture and filter the NPS pollutants carried in the floodwaters. Changes in the volume and flood period can affect the NPS pollution control potential of these wetlands. For additional geographic differences in wetlands, refer to Table 4-4.

Ecosystem Management

Several federal agencies, states, tribes, and many local communities are beginning to outline the role of wetlands and riparian areas in terms of ecosystem management. The underlying tenet of this management strategy is that biodiversity and ecological processes form the core of functioning landscapes (Henjum et al., 1994). If examples of each type of representative ecosystem in a region can be maintained, including wetlands and riparian areas, the species that live in these ecosystems will also be afforded an opportunity to persist (Noss and Cooperrider, 1994). To achieve this, areas of relatively intact, functioning ecosystems that represent biological diversity should be given serious consideration as sites where wetlands and riparian area protection and restoration efforts are focused (Doppelt et al., 1993).

Watershed Analysis

Planning for NPS pollution control in an ecosystem context will require use of new approaches in environmental assessment. Watershed analysis is one such tool that can be used to ensure the functional performance of wetlands and riparian area protection and conservation practices and to evaluate the success of such practices. Watershed analysis is structured around a series of questions whose answers provide a model of ecosystem processes, disturbance history, and risk (Montgomery et al., 1995). The analysis can be conducted at various spatial scales, and used to evaluate the relative contribution of wetlands and riparian areas to maintaining regional or basinwide water quality conditions.

Synoptic Approach

A similar method for conducting broad-scale assessment is the Synoptic Approach developed by EPA (Leibowitz et al., 1992). The approach involves compiling, organizing, and depicting environmental information in a manner that ranks watersheds according to the relative significance and risks associated with wetlands (or other ecosystems). States can use the synoptic approach and related assessment methodologies to refine water quality protection strategies (e.g., geographic prioritization), including plans for NPS control (Daggett, 1994). In Louisiana and Washington State, EPA has conducted studies that use the synoptic approach to assess wetland water quality functions on a landscape scale (Abbruzzese et al., 1990a, 1990b). The synoptic approach considers the environmental effects of cumulative wetland losses. In addition, this approach involves assembling a framework that ranks watersheds according to the relative importance of wetland functions and losses. States are also encouraged to refine their water quality standards applicable to wetlands by assigning wetland-specific designated uses to classes of wetlands (USEPA, 1990).

A number of factors in a watershed should be considered in the development of a wetland conservation plan. Factors such as position in the landscape, present or past land use, and existing modification of the natural hydrology help to define the goals and objectives of a conservation plan and identify problems and opportunities for protection and management.

Table 4-3 provides examples of projects where states have considered regional differences in the assessment, management, and conservation of wetlands and riparian areas.

Watershed Approach in Arkansas
The Arkansas Wetland Strategy does not replace other natural resource plans; it recognizes them and puts wetlands in context with other resource plans, such as nonpoint source pollution management, floodplain management, habitat protection, groundwater protection, and other water quality programs, for decision making at the watershed level. It also provides an ecosystem context by linking with regional wetland plans and priorities. Stakeholders (including wetland scientists, policymakers, landowners, and regulators) concluded that case-by-case wetland permitting does not result in a balanced conservation strategy. Case-by-case permitting tends to be inconsistent and confusing to landowners and usually does not result in "no net loss." The Arkansas Wetland Strategy promotes voluntary, incentive-based, locally lead conservation planning through the implementation of the strategy objectives.
Source: Multi-Agency Wetland Planning Team, 2001.

4.1.2 Assessment of Functions and Values

Practice

Identify existing functions of those wetlands and riparian areas with significant NPS control potential when implementing NPS management practices. Do not alter wetlands or riparian areas to improve their water quality function at the expense of their other functions.

Although wetlands are recognized for their flood control and water quality improvement functions, use of natural wetlands to reduce pollutants in storm water and other forms of runoff can have dramatically adverse effects on wetland systems. Several states have laws that restrict direct conveyance of storm water into natural wetlands. For example, the Washington State Department of Ecology established regulations restricting the placement of storm water management ponds in wetlands. Storm water discharges to wetlands must be treated and controlled to meet state water quality and groundwater quality standards. The hydroperiod and flows of existing site conditions must also be maintained to protect characteristic uses of the wetland (Washington State Department of Ecology, 1992).

In general, the following practices should be avoided:

- Location of surface water runoff ponds or sediment retention basins in wetland systems.
- Extensive dredging and plant harvesting as part of nutrient or metals management in natural wetlands.

Some harvesting within wetlands might be necessary to control the invasion of exotic plants. Extensive harvesting of plants in a wetland for surface water runoff or nutrient management, however, can be very disruptive to the existing plant and animal communities.

Watershed Approach

A watersheds is an area of land that drains to a single stream or other water resources. Watersheds are defined solely by drainage areas and may include multiple landowners or cross political boundaries. The watershed approach is a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within hydrologically defined geographic areas (e.g., watersheds), taking into consideration both ground and surface water flow.

EPA supports watershed approaches that aim to prevent pollution, achieve and sustain environmental improvements, and meet other goals important to the community. Although watershed approaches may vary in terms of specific objectives, priorities, elements, timing, and resources, all should be based on the following guiding principles.

- *Partnerships.*Those people most affected by management decisions are involved throughout and shape key decisions. This ensures that environmental objectives are well integrated with those for economic stability and other social and cultural goals. Partnerships also ensure that the people who depend on the natural resources within the watersheds are well informed and participate in planning and implementation activities.
- *Geographic focus.* Activities are directed within specific geographic areas, typically the areas that drain to surface water bodies or that recharge or overlay groundwaters or a combination of both. Cooperation between multiple landowners and political jurisdictions is essential.
- *Sound management techniques based on strong science and data.* Collectively, watershed stakeholders employ sound scientific data, tools, and techniques in an interactive decision-making process. This process should include
  - Assessment and characterization of the natural resources and the communities that depend on them.
  - Goal setting and identification of environmental objectives based on the condition or vulnerability of resources and the needs of the aquatic ecosystem and the people in the community.
  - Identification of priority problems.
  - Development of specific management options and action plans.
  - Implementation.
  - Evaluation of effectiveness and revision of plans, as needed.

When stakeholders work together, actions are based on shared information and a common understanding of the roles, priorities, and responsibilities of all involved parties. The nature of the watershed approach encourages partners to set goals and targets and to make maximum progress based on available information while continuing analysis and verification in areas where information is incomplete.

Watershed projects should have a strong monitoring and evaluation component. Monitoring is essential to determining the effectiveness of management options chosen by stakeholders. Because many watershed protection activities require long-term commitments from stakeholders, they need to know whether their efforts are achieving real improvements in wetland or riparian area functions.

Operating and coordinating programs on a watershed basis makes good sense for environmental, financial, social, and administrative reasons. For example, by jointly reviewing the results of assessment efforts for NPS pollution control, fish and wildlife habitat protection, and other resource protection programs, managers can better understand the cumulative impacts of various human activities and determine the most critical problems in each watershed. Using this information to set priorities for action allows public and private managers from all levels to allocate limited financial and human resources to address the most critical needs.

The final result of the watershed approach is a plan that is a clear description of resource problems, goals to be obtained, monitoring to be conducted, and identification of sources for technical, educational and funding assistance. The successful plan provides a basis for seeking support and for maximizing the benefits of that support.

Source: USEPA, 1996b.

A study conducted on two similar wetlands in New Jersey demonstrated an increase in erosion associated with the harvesting of vegetation. Vegetation was cut in one of the wetlands and left undisturbed in the other. Banks eroded more than 6 feet in the harvested wetlands while the uncut site exhibited minimal erosion (USEPA, 1995b).

Assessment

The assessment of wetland and riparian areas can provide data needed to identify degradation of functions within the systems and potential sources of the degradation. Several states assess wetlands that are relatively free from impacts to define baseline conditions and establish standards to protect wetlands.

Several assessment approaches can be applied to characterize existing functions of wetlands and riparian areas. The Hydrogeomorphic Approach to the Functional Assessment of Wetlands (HGM) was developed by the Army Corps of Engineers Waterways Experiment Station (USACE Waterways Experiment Station, 1995). HGM establishes procedures for classifying regional wetland types and developing models for assessing the functions of each. HGM is based on the recognition of common hydrologic and geomorphic characteristics of different types of wetland ecosystems and the use of reference systems as the basis of scaling functional attributes of wetlands. With the establishment of reference wetlands, in which functions have already been evaluated, a site being evaluated can be compared to the reference group of the same class. The HGM method represents a rapid assessment approach that can be used to characterize existing functions in wetlands, potential impacts to wetland functions as the result of an activity, and changes in wetland function over time.

Examples of the use of functional assessment tools for various wetland or riparian area applications are provided in Table 4-5 and Appendix F.

Monitoring

Water quality and biological monitoring may be necessary to characterize general conditions and to document changes over time. Monitoring of conditions in wetland or riparian areas, in particular where such areas are providing NPS pollution reduction functions, is important to ensure that healthy habitat conditions are maintained. Water quality monitoring is useful for determining the physical characteristics and chemical composition of a water body at a particular time. A sustained record of water quality sampling makes it possible to determine trends in pollutant loadings. BMPs to protect habitat functions can be implemented where adverse impacts are identified.

One of the most direct and effective ways of evaluating the ecological health or integrity of a wetland is to directly measure the condition of the wetland's biological community. Bioassessment methods can be used to directly measure the long-term biological integrity of wetlands and quickly screen them for signs of impairment. Several states, including Florida, Indiana, Maine, Massachusetts, Minnesota, Montanan, North Dakota, Ohio, and Pennsylvania, are developing biological assessment methods to evaluate the health of their wetlands. Wetland bioassessments can be useful in defining management approaches to maintain and restore wetland condition and in evaluating the performance of protection and restoration activities.

The involvement of volunteers in wetland assessment and monitoring programs is a realistic, cost-effective and beneficial way to obtain important information that might otherwise be unavailable because of a lack of resources at government agencies. Initiatives like Riverwatch, Adopt a Stream, and the Izaak Walton League's Save Our Streams program have been highly successful in maintaining groups of interested volunteers and yielding data useful to scientists, planners, and concerned citizens. A growing number of organizations are training citizens to monitor wetlands.

In addition to providing useful information, these programs have the benefit of educating citizens about wetland functions and empowering citizens to become more active stewards of wetland resources in their communities. Informed citizens can play a key role in encouraging land and water stewardship in all sectors of society, from industry to private homeowners and from housing developers to municipal sewage treatment managers and local planning boards.

Table 4-5 and Appendix F provide examples of situations in which monitoring has been used to characterize wetland and riparian area conditions and changes over time.

A state may need to address any one or a combination of factors in particular circumstances to meet the mandates of the CWA articulated in section 101(a): "to restore and maintain the chemical, physical, and biological integrity of the nation's waters."

4.1.3 Programmatic Approaches

Practice

Use permitting, licensing, certification, and nonregulatory approaches to protect wetland functions.

There are many possible programs, both regulatory and nonregulatory, to protect wetland functions (Table 4-6). Appendix A and Appendix F also provide information on federal, state, nonprofit, and private programs involved in the protection and restoration of wetlands and riparian areas on private lands.

Acquisition

Obtain easements or full fee acquisition rights for wetlands and riparian areas along streams, bays, and estuaries. Numerous federal programs, such as the U.S. Department of Agriculture Wetlands Reserve Program (WRP), the EPA CleanWater State Revolving Fund (SRF), and the Fish and Wildlife Service North American Waterfowl Management Plan can provide assistance for acquiring easements or full title. Acquisition of water rights to ensure maintenance of minimum in-stream flows is another means to protect wetlands or riparian areas. Water rights acquisition can be a critical issue in the arid West. See Table 4-6 and Appendix F for examples of acquisition and easement programs.

Several states have developed landowner guides for wetland protection and management. Table 4-7 provides examples of states that have developed guides. Additional information on protection and management guides is provided in Appendix F.

Provide a mechanism for private landowners and agencies in mixed-ownership watersheds to develop, by consensus, goals, management plans, and appropriate practices and to obtain assistance from federal and state agencies.

Zoning and Protective Ordinances

Restrict activities that have a negative impact on wetlands and riparian areas through implementation of special area zoning and transferable development rights. Identify impediments to wetland protection such as excessive street standards and setback requirements that limit site-planning options and sometimes force development into wetlands.

Winona Wetlands Purchase
The city of Port Townsend, Washington, was able to meet both storm water management objectives and a wetlands preservation goal by obtaining funding from Washington's SRF to purchase an area known as the Winona Wetlands. This wetland acts as a critical storm water basin for the area and provides valuable wildlife habitat. Potential development of the area not only threatened the wetlands but also would result in storm water management problems. By purchasing the wetlands, the city was able to protect a natural storm water management system as well as a wildlife refuge. The city purchased 6.5 acres in Phase I and is currently planning to borrow additional CW-SRF funds for a Phase II purchase of 9 acres. This $400,000 project is part of the National Estuary Program (CWA section 320) for the Puget Sound estuary. A portion of the city's storm water utility fee paid by households is being used to repay the Washington SRF.
Source: USEPA. 1998c.

Chesapeake Bay Program
The Chesapeake Bay Program has developed a compilation of tools to assist local governments in the protection of wetlands, including planning, zoning, and tax incentive approaches that have been useful for protecting wetlands in the Chesapeake Bay region.
Source: USEPA, 1997b.

Water Quality Standards

Several states and tribes have realized the importance of developing and implementing water quality standards that protect the full range of wetland functions.

A significant percentage of wetlands are waters of the United States, as defined in the Clean Water Act. Consider natural water quality functions when specifying designated uses for wetlands, and include biological and hydrologic narrative criteria to protect the full range of wetland functions. Table 4-6 and Appendix F provide examples of cases where water quality standards that specifically address wetland functions have been, or are being, developed.

Regulation and Enforcement

Establish, maintain, and strengthen regulatory and enforcement programs. Where allowed by law, include conditions in permits and licenses issued under CWA sections 401, 402, and 404; state regulations; or other regulations to protect wetlands.

As an example of a linkage to protect NPS pollutant abatement and other benefits of wetlands, a state could determine under CWA section 401 that a proposed discharge or other activity in a wetland is inconsistent with state water quality standards. A state might need to address any one of a combination of factors in particular circumstances to meet the mandates of the CWA articulated in section 101(a) “to restore and maintain the chemical, physical, and biological integrity of the nation’s waters.” Protection of water quality includes protection of multiple elements that together make up aquatic systems, including the aquatic life, wildlife, wetlands and other aquatic habitat, vegetation, and hydrology required to maintain the aquatic system. An activity within a wetland could be determined to be consistent with water quality standards if existing use requirements are met and if the activity does not cause or contribute to significant degradation of the aquatic environment as defined in the guidelines developed under section 404(b)(1) of the CWA (USEPA, 1991).

Restoration

Programs such as USDA’s Conservation Reserve and Wetlands Reserve Program provide opportunities to set aside and restore wetlands and riparian areas. Also, incentives that encourage private restoration of fish and wildlife productivity are often more cost-effective than federal, state or local acquisition.

Education and Training

Education and outreach are essential tools for promoting an understanding of the importance of wetland and riparian areas in maintaining water quality and in developing support for the protection of these habitats and the valuable functions that they perform.

Educate farmers, urban dwellers, and federal agencies on the role of wetlands and riparian areas in protecting water quality and on best management practices (BMPs) for restoring stream edges. Teach courses in simple restoration techniques for landowners. Many States have developed wetlands guides to assist landowners in protecting wetland and riparian areas according to their different needs (see Table 4-7). Appendix A and Appendix F provide additional examples of federal, state, tribal, nonprofit, and private programs that provide financial and technical assistance to landowners for wetland or riparian area protection or restoration.

Provide a mechanism for private landowners and agencies in mixed-ownership watersheds to develop, by consensus, goals, management plans, and appropriate practices and to obtain assistance from federal and state agencies. EPA’s National Estuary Program and the Fish and Wildlife Service’s Bay/Estuary Program are excellent examples of approaches that establish a framework for multiagency program linkage and present opportunities to link implementation efforts aimed at protection or restoration of wetlands and riparian areas.

A number of state and federal agencies carry out programs with compatible NPS pollution reduction goals. For example, Maryland's Nontidal Wetlands Protection Act encourages development of comprehensive watershed plans for addressing wetland protection, mitigation, and restoration issues in conjunction with water supply issues. In addition, the U.S. Army Corps of Engineers (USACE) and EPA administer the CWA section 404 program; USDA implements the Swampbuster, Conservation Reserve, and Wetlands Reserve Programs; EPA, USACE, and states work together to perform advanced identification of wetlands for special consideration (CWA section 404); and states administer both the Coastal Zone Management (CZM) program, which provides opportunity or consistency determinations, and the CWA section 401 certification program, which allows for consideration of wetland protection and water quality objectives.

4.1.4 Preliminary Treatment Practices

Practice

Use appropriate preliminary treatment practices such as vegetated treatment systems or detention or retention basins to prevent adverse impacts on wetland functions that affect NPS pollution abatement.

Land Uses

Land use directly affects the characteristics of runoff. For example, the constituents of runoff from farmland are likely to be different from those in urban runoff. Agricultural runoff tends to be high in nitrogen, phosphorus, bacteria, and suspended sediments; typical pollutants found in urban runoff include sediment, oxygen-demanding substances, nutrients, heavy metals, pesticides, hydrocarbons, increased temperature, and trash and debris (USEPA, 1996a).

The characteristics of runoff are directly affected by land use. Agricultural runoff tends to be high in nitrogen, phosphorus, bacteria, and suspended sediments. Typical pollutants found in urban runoff include sediment, oxygen-demanding substances, nutrients, heavy metals, pesticides, hydrocarbons, increased temperature, and trash and debris.

Different wetland types vary in their ability to handle changes caused by storm water flows and pollutant levels. Where runoff is directly channeled to wetlands, treatment practices, or best management practices (BMPs), should be implemented to maintain the natural functions of the wetland. This may require the use of BMPs designed for water quality improvement, maintenance of natural hydrologic conditions, or both. The principal consideration in the design of a BMP is whether it will provide the level of protection necessary to ensure that the wetland will retain its natural health and functions. BMPs should be selected after carefully considering the combination of variables that influence a wetland and the characteristics of the runoff entering the wetland, as well as the capabilities and applicability of the BMPs being considered (USEPA, 1996a). Several states, including Delaware and Florida, have or are currently developing programs and guidelines for protecting wetlands through the use of BMPs.

Design of Treatment Practices

Properly designed and placed BMPs can effectively protect the functions of natural wetlands from NPS pollution. Natural wetlands, because of their position in the landscape, often directly receive storm water runoff. Large flow volumes, high velocities, increased sedimentation, and long-term pollutant loads delivered in runoff can alter or destroy stable wetland ecosystems and their ability to perform NPS pollution abatement functions. Both structural and nonstructural BMPs can be used to provide preliminary treatment of runoff that might impact a receiving wetland.

The principal consideration in the design of a BMP is whether it will provide the level of protection necessary to ensure that the wetland will retain its natural health and functions.

Often, designing a combination of BMPs is the best approach to protecting existing wetland resources. BMPs in series (sometimes referred to as a “treatment train”) incorporate several storm water treatment mechanisms in sequence to enhance the treatment of runoff. By combining BMPs in series rather than using a single method of treatment for runoff, the efficiency and reliability of pollutant removal can be improved. Examples of serial BMPs that can be used to provide preliminary treatment of runoff headed for wetlands include (1) multiple pond systems, (2) grassed swales combined with detention ponds, and (3) grassed swales leading to vegetated filter strips followed by infiltration trenches.

It is important in the design of BMPs in series to consider the hydrologic characteristics of the existing wetland. The series of BMPs should be designed to ensure that the amount of runoff to the wetland is not decreased or otherwise changed to a degree that negatively affects the function of the wetland. For example, where properly designed BMPs are not used, wetlands can be impacted by the accumulation of sediments resulting from decreased flow velocities as runoff enters the wetland. Increased storm water volumes and velocities associated with development in a watershed may also result in the scouring of wetland substrates if BMPs are not in place to slow and reduce flows. In addition to the hydrologic characteristics of the wetland, the characteristics of the NPS runoff, as well as individual BMP capabilities, design requirements, and cost, are important variables when considering the use of serial BMPs.

Many states and territories have developed manuals that provide information on the proper design of BMPs for storm water and erosion and sediment control. *Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices* (USEPA, 1996a) provides insight into the application of BMPs to protect wetlands from the adverse effects of NPS runoff and provides sources for additional information. Additional information on the application of BMPs for wetland protection can also be found in the Management Measure for Vegetated Treatment Systems.

Programmatic Approaches

Programmatic BMPs can also be used to help ensure that preliminary treatment of runoff is conducted before the runoff enters wetlands. Requiring implementation of erosion and sediment control practices at construction sites is an example of a good programmatic approach for reducing sediment and other pollutant loads to wetlands. Erosion and sediment control programs should provide a good source of design guidelines and make sure that effective sediment control practices are being implemented, based on good design criteria, monitoring of completed installations, good maintenance procedures, and monitoring follow-up to ensure that maintenance is being performed. Examples of states and territories that have developed erosion and sediment control programs are Virginia, Delaware, North Carolina, and Guam.

Additional information on BMPs for use with wetlands can be found in Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices *(USEPA, 1996a).*

For more information on the technical implementation and effectiveness of treatment systems, refer to the Management Measure for Vegetated Treatment Systems and Appendix F.

The Fish and Wildlife Service has a long history of wetlands acquisition, protection, and enhancement. The first national wildlife refuge, Pelican Island, was established in 1903 and was created for its namesake, the brown pelican, a wetland-dependent species. The passage of the Migratory Bird Treaty Act in 1918 and the Migratory Bird Conservation Act of 1929 greatly expanded the Service's role in protecting wetlands and species and their habitats. In 1996 the Service managed 472 national wildlife refuges covering approximately 90 million acres. It is estimated that wetlands constitute more than 35 percent of this total refuge area. Proceeds from the sale of the Federal Migratory Bird Hunting and Conservation Stamp, popularly known as the Duck Stamp, have provided more than $250 million for the acquisition of wetlands habitats for inclusion into the refuge system.
Source: USGS, 1996.

4.2 Cost and Benefits of Practices

Costs to implement this management measure, as well as economic benefits derived from implementing this management measure, are associated with planning, mapping, geographic information systems (GIS), protection programs, and pretreatment. This section describes the economic benefits of protecting wetlands and riparian areas that serve NPS abatement functions. This information is intended to demonstrate the cost savings accrued by implementing the management measure as compared to the costs of not implementing it. Because of the wide diversity of regions throughout the United States, no single cost or economic benefit can be used across the board. Instead, the information below and in Table 4-8 provides examples of such costs and benefits in specific areas of the country. The majority of the costs of protecting wetlands and riparian areas shown in Table 4-8 are the result of the purchase of wetlands or cost avoidance (e.g., cost of retaining wetlands rather than constructing water or waste treatment facilities).

In addition to direct costs (e.g., planning, mapping, protection progress, and pretreatment) associated with protecting natural wetlands that serve NPS pollution abatement functions, there are other planning and outreach costs with corresponding benefits. These planning and outreach costs are associated with activities such as modeling studies for storm water flow and water quality protection, educational programs for stakeholders, and development of comprehensive land use plans that include NPS pollutant controls and wetlands protections. Table 4-9 provides specific examples of planning and outreach costs and associated benefits.

Estimating the costs to control NPS pollution nationwide is a difficult task. Critical information, such as identification of waters contaminated with nonpoint pollution and the contribution of each of those sources, is not readily available at the local level, much less at a national level. EPA has estimated the annual costs of controlling three major sources (agriculture, silviculture, and animal feeding operations) of nonpoint source pollution to be $9.4 billion, an amount that represents one of the few systematic attempts at estimating such costs nationwide (GAO, 1999). Part of this cost is attributed to protecting and restoring wetlands and riparian areas.

There are a number of federal and state programs available to help both public and private groups preserve and protect wetlands and riparian areas. Some of these programs are summarized in Appendix F.

The benefits of preserving wetlands and riparian areas in terms of reducing NPS pollution are well recognized. Representative studies of the kind that document benefits are summarized in Table 4-1. Wetlands have important filtering capabilities for intercepting surface-water runoff from higher dry land before the runoff reaches open water. In performing this filtering function, wetlands save communities a great deal of money. For example, a 1990 study showed that without the Congaree Bottomland Hardwood Swamp in South Carolina, the area would need a $5 million wastewater treatment plant USEPA, 1996b. The value of a wetland to a community can be estimated based on the wetland's ability to abate NPS pollution. For example, wetlands near cities have been estimated to be worth $16,188 per hectare for their ability to clean water, recycle nutrients, recharge aquifers, control floods, and support fish and wildlife (Abramovitz, 1997).

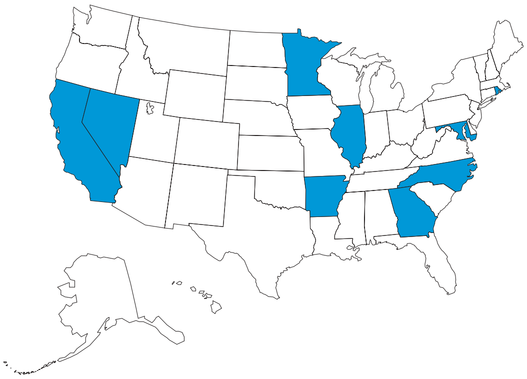
The Minnesota Department of Natural Resources places a value of $665 per acre per year (in 1996 dollars) on the ability of wetlands to remove nutrients and sediments from the environment. In an economic assessment of wetland mitigation in northwest Minnesota, Sip et al. (1998) used a value of $175 per acre per year as a proxy for the value of water quality protection.

It is estimated that riparian forest buffers can remove 21 pounds of nitrogen per acre each year for $0.30 per pound and about 4 pounds of phosphorus per acre each year for $1.65 per pound. The Interstate Commission for the Potomac River Basin estimates that urban retrofit of BMPs to remove 20 percent of current nutrient runoff will cost approximately $200 per acre, or $643,172,600 for the entire Chesapeake Bay basin. In the same study, estimated costs of reducing runoff from highly erodible agricultural land are $130 per acre, or $68,758,430 for the basin.

Many other economic benefits of wetlands have also been described by a number of studies and reports. A wealth of natural products are harvested from wetlands, including fish and shellfish, blueberries, cranberries, timber, and wild rice, as well as medicines that are derived from wetland soils and plants. Many of the nation's fishing and shellfishing industries harvest wetland-dependent species; the catch is valued at $15 billion per year. The coastal marshes of Louisiana alone produced 1.2 billion pounds of commercial fish and shellfish in 1991, a harvest worth $244 million. Wetlands also have recreational, historical, scientific, and cultural value. More than half of all U.S. adults (98 million) hunt, fish, birdwatch or photograph wildlife. They spend a total of $59.5 billion annually (USEPA, 1996b).

Current state and local requirements for erosion and sediment control (ESC) increase the cost of development. On a typical site, costs of ESC average $500 to $1,500 per cleared acre. Average costs for subdivision development include $4,000 per acre for clearing and $8,000 per acre for sediment control. Forest conservation and riparian buffers sharply reduce ESC costs. Forest conservation would keep soil on-site, resulting in less time and labor regrading, stabilizing, and relandscaping the site.

Table 4-1. Effectiveness of Natural Wetlands and Riparian Areas for NPS Pollutant Removal



Measurements taken throughout the United States show the NPS pollutant abatement functions of wetlands and riparian areas. Results of studies in various states (refer to map graphic) are shown in the table below. Additional information about each study cited in the table is provided in Appendix F at the back of the document.

Number 1 Study Pollutant reduction by floodplain deposition in bottomland hardwood forest **Solids** 50%[1] **NO_3** 80% **P** 50% **Example Projects** Cache River, Arkansas
Number 2 Study Nitrate retention in a third-order stream **NO_3** 14% **Example Projects** Little Lost Man Creek, California
Number 3 Study Nutrient removal in a mixed hardwood, riparian forest **NO_3** 67% **P** 25% **Ca** 42% **Mg** 22% **Example Projects** Tifton, Georgia
Number 4 Study Sediment and phosphorus retention in a riparian wetland **Solids** 3% **P** 0.4% **Example Projects** Heron Pond, Illinois
Number 5 Study Nitrate and sulphate reduction in a riparian forested wetland **NO_3** 86% **SO_4** 25% **Example Projects** Rhode River 1, Maryland
Number 6 Study Removal of nutrients in a riparian deciduous hardwood forest **NO_3** >80% **P** >80% **Example Projects** Rhode River 2, Maryland
Number 7 Study Phosphorus and nitrate export and removal in a forested riparian area **NO_3** 79% **P** 80% **Example Projects** Rhode River Subwatershed, Maryland
Number 8 Study Retention of sediment and nutrient loads from storm water runoff by an urban wetland **Solid**s 97%[2] , 76%[3] **N** 47% **P** 48% **Example Projects** Fish Lake, Minnesota
Number 9 Study Nitrate reduction by a forested riparian buffer strip **NO_3** 93% **Example Projects** Beaver Dam Creek Watershed, North Carolina
Number 10 Study Removal of phosphate in a riparian forest **P** 50% **Example Projects** Cypress Creek 1, North Carolina
Number 11 Study Sediment trapping efficiency in riparian areas **Solids** 84-90%[4] **Example Projects** Cypress Creek 2, North Carolina
Number 12 Study Nitrate removal by wetland and riparian areas in watershed headwaters **NO_3** 99% **Example Projects** Lake Tahoe, Nevada

Number 13 Study Seasonal groundwater nitrate removal by wetlands **NO_3** 80% **Example Projects** Kingston 1, Rhode Island
Number 14 Study Nitrate retention by riparian forest with upland wetland transition zones and red maple wetlands **NO_3** 59% **Example Projects** Kingston 2, Rhode Island
Note: NO_3, nitrates; N, organic nitrogen; P, phosphorus; SO_4, sulfate; Ca, calcium; Mg, magnesium. [1] Total suspended solids. [2] Nonvolatile solids. [3] Volatile solids. [4] Sediment.

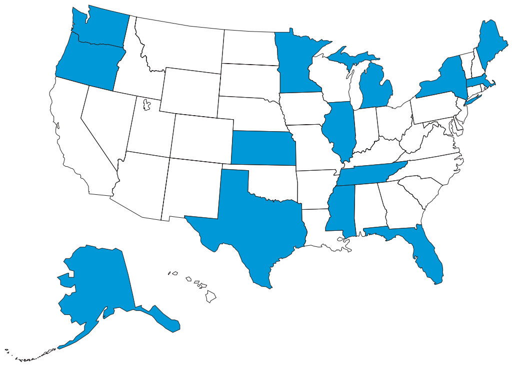
Table 4-2 Federal Programs and Acts That Affect Wetlands in the United States

Program or Act Coastal Barriers Resources Act (P.L. 96-348) (1982)	**Agency** NOAA	**Effect of Program** Designates various undeveloped coastal barrier islands for inclusion in the Coastal Barrier Resources System. Designated areas are ineligible for federal financial assistance that may aid development.
Program or Act Coastal Wetland Planning, Protection, and Restoration Act (P.L. 101-646) (1990	**Agency** USACE, FWS, EPA, NMFS	**Effect of Program** Provides for interagency wetlands restoration and conservation planning and acquisition in Louisiana, other coastal states, and the trust territories.
Program or Act Coastal Zone Management Act (P.L. 92-583) (1972)	**Agency** NOAA	**Effect of Program** Provides federal funding for wetlands programs in most coastal states, including the preparation of Coastal Zone Management Plans.
Program or Act Emergency Wetlands Resources Act of 1986 (P.L. 99-645)	**Agency** FWS	**Effect of Program** Pays debts incurred by FWS for wetlands acquisition and provides additional revenue sources.
Program or Act Endangered Species Act of 1973 (P.L. 93-205)	**Agency** FWS	**Effect of Program** Provides for the designation and protection of wildlife, fish, and plant species that are in danger of extinction.
Program or Act Estuary Protection Act (P.L. 90-454) (1968)	**Agency** DOI	**Effect of Program** Authorized the study and inventory of estuaries and the Great Lakes, and provided for management of designated estuaries between DOI and the states.
Program or Act Estuary Restoration Act of 2000(P.L. 106-457) (2000)	**Agency** USEAP, NOAA, USACE, FWS, USDA	**Effect of Program** Promotes the restoration of estuary habitat, develops a national estuary habitat restoration strategy, provides federal assistance and promotes efficient financing of such projects, and enhances monitoring and research capabilities.
Program or Act E.O. 11990, Protection of Wetlands (1977)	**Agency** AFA	**Effect of Program** Requires federal agencies to minimize impacts of federal activities on wetlands.
Program or Act E.O. 11988, Protection of Floodplains (1977)	**Agency** AFA	**Effect of Program** Requires federal agencies to minimize impacts of federal activities on floodplains.
Program or Act Federal Aid in Wildlife Coordination Act of 1956	**Agency** DOI	**Effect of Program** Authorizes the development and distribution of fish and wildlife information and the development of policies and procedures relating to fish and wildlife.
Program or Act Food, Agriculture, Conservation, and Trade Act of 1990 (P.L. 101-624)	**Agency** NRCS	**Effect of Program** Wetland Reserve Program purchases perpetual nondevelopment easements on farmed wetlands. Subsidizes restoration of croplands to wetlands.
Program or Act Food Security Act of 1985 (Swampbuster) (P.L. 99-198)	**Agency** FSA, FWS	**Effect of Program** "Swampbuster" program suspends agricultural subsidies for farmers who convert wetlands to agriculture. Conservation Easements program allows FmHA FSA to eliminate some farm debts in exchange for long-term easements that protect wetlands and other areas.
Program or Act Migratory Bird Hunting and Conservation Stamps (1934) (Ch. 71, 48 Stat. 452)	**Agency** FWS	**Effect of Program** Acquires wetland easements using revenues from fees paid by hunters for duck stamps.
Program or Act National Environmental Policy Act of 1969 (P.L. 91-190)	**Agency** AFA	**Effect of Program** Requires the preparation of an environmental impact statement for all major federal actions significantly affecting the environment.
Program or Act North American Waterfowl Management Plan (1986)	**Agency** FWS	**Effect of Program** Establishes a plan for managing waterfowl resources by various methods, such as acquiring wetlands.
Program or Act North American Wetlands Conservation Act (1989) (P.L. 101-233	**Agency** FWS	**Effect of Program** Encourages public/private partnerships by providing matching grants to organizations for protecting, restoring, or enhancing wetlands.
Program or Act Rivers and Harbors Act of 1938 (52 Stat. 802)	**Agency** USACE	**Effect of Program** Provides that "due regard" be given to wildlife conservation in planning federal water projects.
Program or Act U.S. Tax Code Tax Reform Act of 1986 (P.L. 99-514)	**Agency** IRS	**Effect of Program** Provides deductions for donors of wetlands and to some nonprofit organizations.
Program or Act Water Bank Act (1970) (P.L. 91-559)	**Agency** FSA	**Effect of Program** Leases wetlands and adjacent uplands from farmers for waterfowl habitat for 10-year periods.
Program or Act Water Resources Development Act of 1976, 1986, 1988, 1990 (P.L.'s 94-587, 99-662, 100-676, 101-640)	**Agency** USACE	**Effect of Program** States that future mitigation plans for federal water projects should include "in kind" mitigation for bottomland hardwood forests.
Program or Act Wetlands Loan Act (1961) (P.L. 87-383	**Agency** FWS	**Effect of Program** Provides interest-free loans for wetland acquisition and easements.
Program or Act Wild and Scenic Rivers Act (P.L. 90-542) (1968)	**Agency** DOI, USDA	**Effect of Program** Protects designated river segments from alterations without a permit.

Note: AFA, all federal agencies; ASCS, Agricultural Stabilization and Conservation Service; DOI, Department of the Interior; EPA, Environmental Protection Agency; FSA, Farm Service Agency; FmHA, Farmer's Home Administration; FWS, Fish and Wildlife Service; IRS, Internal Revenue Service; NMFS, National Marine Fisheries Service; NOAA, National Oceanic and Atmospheric Administration; USACE, U.S. Army Corps of Engineers; USDA, U.S. Department of Agriculture; P.L., Public Law; E.O., Executive Order.

Source: Excerpted from USGS, 1996.

Table 4-3. Wetlands or Riparian Areas



Practice: Evaluate and document the NPS control potential of wetlands and riparian areas on a watershed or landscape scale.

This table provides some examples from different locations in the United States of the kinds of activities that can help implement this practice. For more information about the examples, refer to Appendix F at the back of the document.

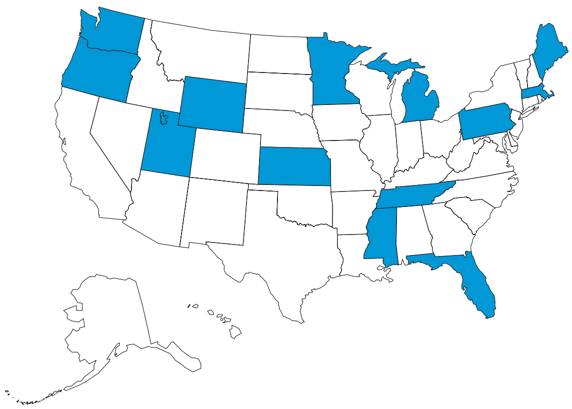
Implementation Activities Use a landscape approach to evaluate wetland water quality functions. **Example Projects** Local Wetland Management Plans, Arkansas, Wetland Protection, Florida, Wetland Assessment, Illinois, Grand Traverse Bay Watershed Initiative, Michigan, Wetland Protection, Rhode Island, Rivers and Wetlands Program, Tennessee, Synoptic Assessment Approach, Washington
Implementation Activities Use watershed analysis as a tool to ensure functional performance. **Example Projects** Wetland Protection, Florida, Synoptic Assessment Approach, Washington
Implementation Activities Use tools such as the synoptic approach to construct broad scale assessments. **Example Projects** Wetland Assessment, Illinois, Pearl River Basin, Mississippi, Synoptic Assessment Approach, Washington
Implementation Activities Recognize geographic differences when considering wetland or riparian area functions within a watershed. **Example Projects** Reference Reach Monitoring Program, Kentucky, Wetland Conservation Plan, Minnesota, Wetland Conservation Plan, Texas, Synoptic Assessment Approach, Washington
Implementation Activities Develop wetland conservation plans that consider wetlands and riparian areas on a watershed or landscape scale. **Example Projects** Wetland Conservation Plan, Maine, Grand Traverse Bay Watershed Initiative, Michigan, Watershed Initiative Program, Michigan, Wetland Protection, New York, Wetland Conservation Plans, Oregon, Rivers and Wetlands Program, Tennessee, Wetland Conservation Plan, Texas, Synoptic Assessment Approach, Washington, Wetlands Conservation Plan/Outreach (Bad River Band), Watershed Demonstration Project (Flathead Reservation), Watershed Protection (Umatilla), Wetland Conservation Program (Nez Perce), Wetlands Conservation Project (Hopi)
Implementation Activities Consider water quality functions of wetlands and riparian areas during the planning process. **Example Projects** Wetland Protection, Massachusetts, Wetland Conservation Plans, Oregon

Table 4-4. Descriptions of Specific Wetland Types

Pocosin Wetlands	Pocosin wetlands occur along the Atlantic seaboard's lower coastal plain, from southern Virginia to northern Florida. Pocosin wetlands are found in ridge and swale topography, as well as in flat areas of the lower coastal plain, in depressions of the Carolina Bays, in areas of springs and seeps in the upper coastal plain, and in the floodplains of streams. The substrates of pocosins are not very permeable so groundwater beneath the wetland, which has a high mineral content, does not come into contact with the low-mineral-content water and soil of the pocosin. Water movement occurs as seepage at the pocosin's margins that flows to streams, or as direct flow to salt marshes in estuarine areas.
Cienegas	Cienega is a term that usually applies to a mid-elevation wetland characterized by permanently saturated, highly organic, reducing soils. Cienegas are perpetuated by permanent, scarcely fluctuating sources of water and are rarely subject to harsh winter conditions. They occur at mid-elevations of semidesert grasslands and are usually associated with perennial springs and headwater streams.
Playa Lakes	The term playas generally refers to areas occupied by temporary shallow lakes that have internal drainage, usually in arid to semiarid regions of the southern Great Plains. They are not part of an integrated surface drainage system, but are related to geologic fracture areas. Playa floors are plate-like with relatively constant water depth throughout much of the basin. Very few playas are directly associated with groundwater, and playas usually fill only from precipitation and irrigation runoff. Most playas are dry during one or more periods of each year, usually late winter, early spring, and late summer. There is no surface water outflow; playas lose their water by evaporation, seepage, and irrigation use.
Riverine or Riparian Wetland Areas of the Southwest	Riverine or riparian wetlands exist along the margins of rivers, behind natural levees, in oxbows and floodplains. Riverine wetlands in arid climates are limited shoreward by desert and riverward by water depth and scouring. These wetlands are transitory. They develop rapidly only to be removed by channel-straightening floods, or they proceed toward an upland community after drying. In the American Southwest, riverine marshes are located primarily in broad alluvial valleys.
Prairie Potholes	The prairie pothole region of the northern United States consists of North Dakota, western Minnesota, northeastern South Dakota, and upper central Iowa. A pothole is defined as a surface depression occurring in glacial sediments, containing water from precipitation, surface runoff, and groundwater. Potholes have an average depth of about 2 to 5 feet and can range in size from a few hundred square yards up to several thousand square miles. These wetlands are not usually associated with any regional network of stream channels, but they are related to local and regional groundwater systems. The hydroperiods in potholes range from temporarily to permanently flooded, and these differences cause the development of diverse vegetation zones such as wet meadow, shallow marsh, and deep marsh. Prairie potholes lose water through evaporation, transpiration, and seepage to groundwater.
Bogs and Fens	Bogs have acidic, fibrous, spongy, nutrient-poor organic soil, and their organic plant material consists mostly of sphagnum moss. Because of their location at or above the local groundwater table, bogs acquire most of their water from precipitation. Fens represent a transitional stage between marshes and bogs. Fens obtain water not only directly from precipitation, but also by surface runoff and groundwater seepage. Acidic water with a very low mineral content is typical of bogs; fens are characterized by the reverse. Mineralized fen water originates from groundwater, whereas precipitation produces the high-acidity, low-mineral water content of a bog.
Bottomland Hardwoods	Bottomland hardwoods are forested wetlands in the river valley floodplains of Missouri, the southern Atlantic Coastal Plain, and the Gulf states of Alabama, Mississippi, and Louisiana. They occupy the broad floodplains, seldom exceeding a width of 5 miles. Seasonal hydrology in these wetlands affects surface water and groundwater movement. In drier seasons, floodwaters and lateral groundwater movement serve as the dominant inputs. Other input sources include overbank flooding from the main channel, flooding from small tributary streams, lateral overland flow from valley sides, lateral groundwater flow from valley-side rock formations, and movements of groundwater parallel to the main river channel. Recharge can also occur in the form of bank storage. As water levels rise, water moves laterally from the channel to the adjacent floodplain.
Cypress Dome Wetlands	Cypress dome wetlands occur in southern Georgia and Florida. The term cypress dome is defined as a hardwood forested wetland occurring in seasonally or permanently wet saucer-shaped depressions. These wetlands are small, usually not exceeding 25 acres, and are dominated by pond cypress trees. The trees assume a characteristic dome-shaped profile, with the smaller trees toward the edges and the larger trees in the middle due to the occurrence of wildfire, which often burns only the outer, smaller trees. Cypress domes occur in flat areas where the water table is close to the surface; this surface water is connected to shallow aquifers. Primary hydrologic inputs to cypress dome wetlands are rainfall and surface water inflow. Water is lost through evapotranspiration and seepage to groundwater systems.
Permafrost/ Tundra Wetlands	Permafrost/Tundra wetlands occur in the interior of Alaska and are the western extension of the wetland complexes of northern Canada. Permafrost is the most important characteristic that distinguishes the hydrology of these wetlands. Wetlands produced by permafrost include seasonal thaw ponds, shallow emergent wetlands, partially drained lake basins, and wetlands in wet and dry tundra. The term muskeg means peatland, and it constitutes the organic content of these wetlands. Precipitation is the main water input because of impermeable conditions created by permafrost. Very little water is lost or received to or from stream and groundwater flow.
Vernal Pools	Vernal pools are naturally occurring depressional wetlands that are covered by shallow water for variable periods from winter to spring but may be completely dry for most of the summer and fall. These wetlands range in size from small puddles to shallow lakes. Although generally isolated, they are sometimes connected to each other by small drainages known as vernal swales. Beneath vernal pools lies either bedrock or a hard clay layer in the soil that helps keep water in the pool. The pools collect water during winter and spring rains, changing in volume in response to varying weather patterns. During a single season, pools may fill and dry several times. In years of drought, some pools might not fill at all.

Source: USEPA 1996a

Table 4-5. Assessment of Functions and Values for Protection Wetlands or Riparian Areas

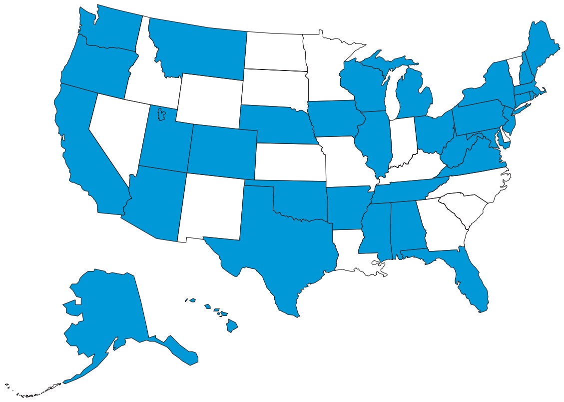


Practice: Identify existing functions of those wetlands and riparian areas with significant NPS control potential when implementing NPS management practices. Do not alter wetlands or riparian areas to improve their water quality function at the expense of their other functions.

This table provides some examples from different locations in the United States of the kinds of activities that can help implement this practice. For more information about the examples, refer to Appendix F at the back of the document.

Implementation Activities Identify and evaluate existing NPS functions of wetland and riparian areas. **Example Projects** Wetland Conservation Plans, Oregon, Wetland Protection, Rhode Island, Wetland Protection, Guam, Wetlands Protection Plan (Rincon)
Implementation Activities Apply assessment tools to characterize existing functions in wetlands. **Example Projects** Wetland Protection, Florida, Water Quality Assessment, Kansas, Meadows Golf Club, Michigan, Reference Wetlands Project (MN), Pearl River Basin, Mississippi, Rivers and Wetlands Program, Tennessee, Matheson Preserve, Utah, Synoptic Assessment Approach, Washington, Green River, Wyoming, Wetlands Protection Plan (Rincon), Wetlands Project (Santa Clara Pueblo)
Implementation Activities Use assessment tools to evaluate potential impacts resulting from activities within the watershed. **Example Projects** Reference Wetlands Project, Minnesota, Pearl River Basin, Mississippi, Rivers and Wetlands Program, Tennessee, Synoptic Assessment Approach, Washington, GIS Assessment, Virgin Islands
Implementation Activities Monitor wetlands throughout watersheds to characterize general conditions and changes over time. **Example Projects** Water Quality Assessment, Kansas, Reference Reach Monitoring Program, Kentucky, Reference Wetlands Project, Minnesota, Wetland Conservation Plan, Maine, Wetland Water Quality Standards, New Hampshire, Wetland Restoration/Creation Site Registry, Pennsylvania, Rivers and Wetlands Program, Tennessee, Matheson Preserve, Utah, Wetland Water Quality Standards (Miccosukee), Wetlands Protection Plan (Rincon), Wetlands Project (Santa Clara Pueblo)
Implementation Activities Characterize unaltered wetlands to define baseline conditions and establish wetland protection standards. **Example Projects** Water Quality Assessment, Kansas, Watershed Initiative Program, Michigan, Reference Wetlands Project, Minnesota

Table 4-6. Programmatic Approaches to Protecting Wetlands and Riparian Areas

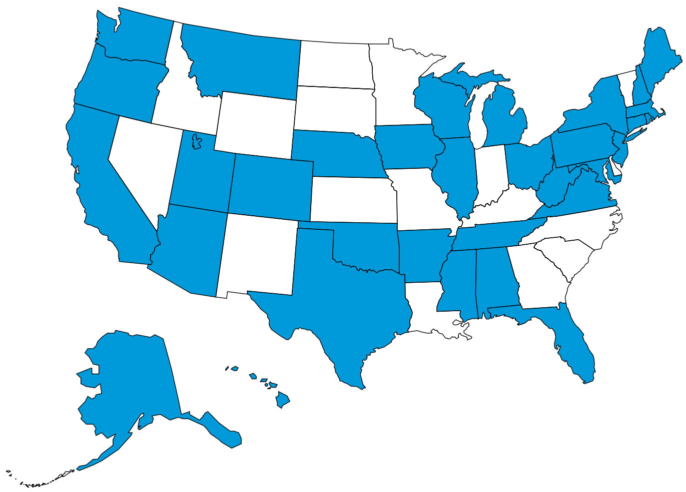


Practice: Conduct permitting, licensing, certification, and nonregulatory NPS pollution abatement activities in a manner that protects wetland functions.

This table provides some examples from different locations in the United States of the kinds of activities that can help implement this practice. For more information about the examples, refer to Appendix F at the back of the document.

Implementation Activities No information given **Example Projects** Wetland Protection, Florida, Wetland Protection, Massachusetts, Nontidal Wetlands Protection Act, Maryland, Wetland Protection, Michigan
Implementation Activities Protect sensitive lands along watercourses from encroachment. **Example Projects** Freshwater Protection Act Rules, New Jersey, Conservation Easement Purchase, Ohio, Wetlands Conservation Plan, Oregon, Wetland Protection, Rhode Island, Comprehensive Plan Policy, Virginia, Mangrove Protection, Puerto Rico
Implementation Activities Require ecological transition areas or buffers adjacent to wetlands. **Example Projects** Wetland Protection, Connecticut, Wetland Protection, Massachusetts, Forest Buffer Legislation, Maryland, Freshwater Protection Act Rules New Jersey, Wetland Protection, New York, Wetland Protection, Rhode Island, Coastal Management Program (American Samoa)
Implementation Activities Develop regulatory programs to counteract encroachment resulting from zoning requirements. **Example Projects** Wetlands Regulatory Program, Washington
Implementation Activities Develop tools for determining proper buffer widths. **Example Projects** Buffer Zone Guidelines, Florida, Agricultural Experiment Station, New Jersey,Wetland Water Quality Standards, New Hampshire, State Water Quality Standards, Wisconsin, Wetland Water Quality Standards (Miccosukee), Wetlands Protection Program (Narragansett), Wetlands Program (Pueblo of Laguana)
Implementation Activities Develop wetland water quality standards. **Example Projects** Landowner's Guide, Arkansas, Wetland Conservation Guide, California, Landowning Colorado Style, Colorado, Wetlands Assistance Guide, Maryland, Watershed Initiative Program, Michigan, Ohio Wetlands, Ohio, Protecting Darby Creek, Ohio, Wetlands Conservation Guide, Oregon, Wetlands Assistance Guide, Texas, Wetlands Conservation Plan, Texas, Wetland Habitat Alliance of Texas, Texas
Implementation Activities Provide a mechanism for private landowners to obtain wetlands assistance. **Example Projects** Huichica Creek Vineyard, California, Hamakau Wetlands, Hawaii, Tiburon Golf Course, Nebraska, Rivers and Wetlands Program, Tennessee, Wetland Conservation Grant, Tennessee, Wetland Conservation Plan, Texas, Matheson Preserve, Utah, Riparian Restoration Demonstration, Virginia, Riparian Task Force, West Virginia, Wetland Conservation Plan/Outreach (Bad River Band), Watershed Demonstration Project (Flathead Reservation), Wetlands Conservation Project (Hopi), Wetlands Outreach (MITC), Wetlands Protection Program (Narragansett), Wetlands Outreach (Red Lake Band), Watershed Protection (Umatilla), Wetland Community Park (Umatilla)
Implementation Activities Provide outreach and education support for wetland and riparian area protection and restoration. **Example Projects** Gulf Oak Ridge, Alabama, Ramsey Canyon, Arizona, Tahoe Conservancy, California, Wetland Restoration Program, Iowa, Teton River Basin, Idaho, Southern Lake Michigan, Indiana, Wetland Protection, Massachusetts, Pine Butte Swamp, Montana, Wetland Acquisition, Michigan, Coastal Preserves, Mississippi, Green Acres Program, New Jersey, Conservation Easement Purchase, Ohio, West Eugene Wetlands Project, Oregon, Hackberry Flat, Oklahoma, Wetland Restoration/Creation Site Registry, Pennsylvania, Wetland Conservation Grant, Tennessee, Wetland Restoration Site Registry, Texas, Winona Wetlands Purchase, Washington
Implementation Activities Develop wetland management plans that specify practices for protection. **Example Projects** Local Wetland Management Plans, Arkansas, Wetland Conservation Strategy, Illinois, Nontidal Wetland Protection Act, Maryland, Wetland Conservation Plans, Oregon, Wetland Conservation Plan, Maine, Wetland Protection, Massachusetts, Watershed Initiative Program, Michigan, Pine Butte Swamp, Montana, Wetlands Conservation Plan, Texas, Coastal Management Program (American Samoa), Wetlands Conservation Plan/Outreach (Bad River Band), Watershed Demonstration Project (Flathead Reservation), Wetlands Conservation Project (Hopi), Wetlands Protection Program (Narragansett), Wetland Conservation Program (Nez Perce), Wetlands Protection Program (Pueblo of Acoma), Wetlands Program (Pueblo of Laguana), Wetlands Conservation Plan (Sisseton-Wahpeton Dakota Nation), Watershed Protection (Umatilla), Wetlands Conservation Plan (Warm Springs)

Table 4-7. Examples of State Guides for Wetlands Protection and Management



Landowner's Guide, Arkansas - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, State Nonregulatory Program, Federal Nonregulatory Program, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
Wetland Conservation Guide, California - Explanation of Definition, Characterization of Functions, State Regulatory Programs, State Nonregulatory Programs, Federal Nonregulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
Landowning Colorado Style, Colorado - Federal Nonregulatory Program, Landowner Options, Contacts
Wetlands Assistance Guide, Maryland - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, State Nonregulatory Programs, Federal Nonregulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
Living With Michigan's Wetlands, Michigan - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, State Nonregulatory Programs, Federal Nonregulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
Stream Managment Guide, Montana - Characterization of Functions, State Regulatory Programs, Federal NonRegulatory Programs, Landowner Options
Wetland Regulation Guidebook, New York - Characterization of Functions, State Regulatory Programs, Federal NonRegulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts
Ohio Wetlands, Ohio - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, Federal NonRegulatory Programs, State Nonregulatory Programs, Federal Nonregulatory Programs, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
Wetlands Conservation Guide, Oregon - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, Federal NonRegulatory Programs, State Nonregulatory Programs, Federal Nonregulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
Wetlands Assistance Guide, Texas - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, State Nonregulatory Programs, Federal Nonregulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts, Case Studies
A Wetlands Workbook, Utah - Explanation of Definition, Characterization of Functions, Characterization of Loss, State Regulatory Programs, Federal Nonregulatory Programs, Landowner Options, State Sources for Assistance, Federal Sources for Assistance, Contacts

Table 4-8. Costs and Economic Benefits Associated with Protecting Wetlands

Examples from throughout the United States show the expected cost of many types of wetland and riparian protection projects, as well as their value to the respective communities. For many of these projects, the cost to install structural or conventional technologies to replace the functions of wetlands have been shown to be much greater than the cost of the protection measure. Results of studies in various states (refer to map graphic) are shown in the table below. Additional information about each study cited in the table is provided in Appendix F.

Study Dredging costs presumed due to wetland loss **Cost of Conventional Project** $2.3 million in dredging costs **Cost of Wetland** **Estimated Benefit of Wetlands** Reduced sedimentation in shipping channel **Example Projects** Redwood City, California
Study Kissimmee Prairie, Florida, Basin—land acquisition **Cost of Conventional Project** **Cost of Wetland** $33,837,767 **Estimated Benefit of Wetlands** The acquisition of Kissimmee Prairie State Preserve provided tax incentives to the landowner and has provided an excellent public/private partnership for watershed protection **Example Projects** Kissimmee Prairie Watershed, Florida
Study Improving a sewage treatment plant for nitrogen removal compared to the function of a 3-mile stretch of wetland **Cost of Conventional Project** $70 billion **Cost of Wetland** **Estimated Benefit of Wetlands** $3 million/year **Example Projects** Alcovy River, Georgia
Study Valuation of estuarine wetlands for wastewater treatment **Cost of Conventional Project** $368 to $2,204/acre for wastewater treatment **Cost of Wetland** **Estimated Benefit of Wetlands** $82/acre to $157/acre; $4,626/acre (industrial wastewater) **Example Projects** Barataria-Terrebonne Estuary, Louisiana
Study Construction of a dam versus preserving wetlands **Cost of Conventional Project** $100 million (dam construction) **Cost of Wetland** $10 million (wetland purchases) **Estimated Benefit of Wetlands** $90 million (one-time structural costs avoided) and $3.2 million in reduced flood damage in 1987 **Example Projects** Natural Storage in the Charles River Valley, Massachusetts
Study Cost to replace water storage capability of a wetland **Cost of Conventional Project** $300/acre-foot **Cost of Wetland** **Estimated Benefit of Wetlands** $1.5 million/year for the estimated 5,000 acres of wetlands lost each year **Example Projects** Minnesota Department of Natural Resources, Minnesota
Study Savings of constructed wetlands vs. conventional method **Cost of Conventional Project** $50 million **Cost of Wetland** **Estimated Benefit of Wetlands** **Example Projects** Staten Island Bluebelt Project, New York
Study Wastewater costs due to wetland loss **Cost of Conventional Project** $1.5 million **Cost of Wetland** **Estimated Benefit of Wetlands** $1.5 million sewer system installation **Example Projects** East Goshen, Pennsylvania

Table 4-9. Planning and Outreach Costs and Benefits

Additional costs are associated with the planning of wetlands protection, as well as with public outreach and education. Some examples of such costs are identified below. More information on these examples is provided in Appendix F.

Study GIS Flood Management and Water Quality Models, Prince George's County

Cost of Project $450,000

Estimated Benefit Exceptional cost and time savings have resulted from use of the Geo-STORM application, and the methods are more consistent than previous studies.

Example Projects GIS, Maryland

Study Monroe County Wetlands Education for schools and public officials

Cost of Project $20,000 plus $9,000 in-kind services

Estimated Benefit There is a high demand for the wetland field trip workshop. "More land use decision-makers and residents are receptive to the placement of constructed wetlands in their communities."

Example Projects Wetland Education Program, New York

Study Projects Development of wetland protection and conservation ordinance

Cost of Project $50,000 to $100,000

Estimated Benefit none stated

Example Projects Grand Portage Reservation (Tribal)

Study Henrico County's Environmental Program: Protection of Water Resources–regulatory strategies (a watershed-based storm water management program that is protective of wetlands)

Estimated Benefit Conflicts between developers and homebuilders are reduced because of plan reviews and approvals relating to U.S. wetlands and waters. Accidental impacts to wetlands or streams are avoided.

Example Projects Henrico County's Environmental Program, Virginia

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Study Duck, Apple, and Ashwaubenon Creeks (DAA) Priority Watershed Project–comprehensive planning and implementation of NPS control measures; establishment of water quality goals and objectives

Cost of Project $21,800,000 (DAA Nonpoint Source Control Plan

Estimated Benefit Water quality and quantity will be improved, and the economy and the quality of life in northeastern Wisconsin will benefit directly from those improvements

Example Projects Wisconsin Department of Natural Resources, Oneida Indian Reservation, Wisconsin